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Arnett et al.

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(54) **COMMUNICATION JACK CONNECTOR CONSTRUCTION FOR AVOIDING DAMAGE TO CONTACT WIRES**

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Related U.S. Application Data

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(60) Provisional application No. 60/345,662, filed on Jan. 2, 2002.

(51) **Int. Cl.**[7] **H01R 24/00**
(52) **U.S. Cl.** **439/676**
(58) **Field of Search** 439/676, 344, 439/941, 76.1, 557, 188; 333/1

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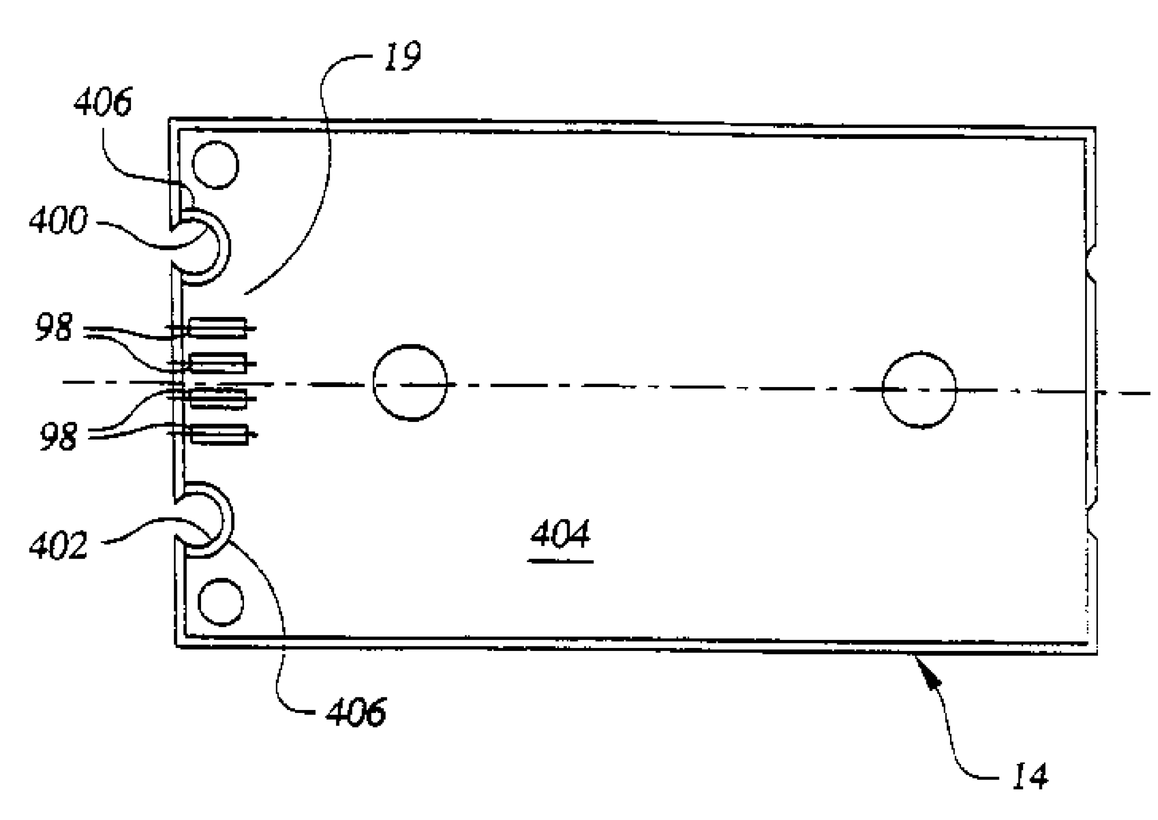
(57) **ABSTRACT**

A communication jack connector includes a wiring board having a front region, and a number of contact wires for engaging and making electrical connections with corresponding terminals of a conforming plug connector. The contact wires have free ends formed to be deflected resiliently in a direction toward the front region of the wiring board when engaging the plug connector. At least one clearance opening is formed in the wiring board at a location where the free end of a corresponding contact wire would otherwise contact an upper surface of the board when deflected by the plug connector. The clearance opening is dimensioned so that part of the free end of the contact wire deflects into the opening a certain distance from the upper surface of wiring board while the contact wire maintains sufficient resilient force to connect electrically with the corresponding terminal of the plug connector.

6 Claims, 7 Drawing Sheets



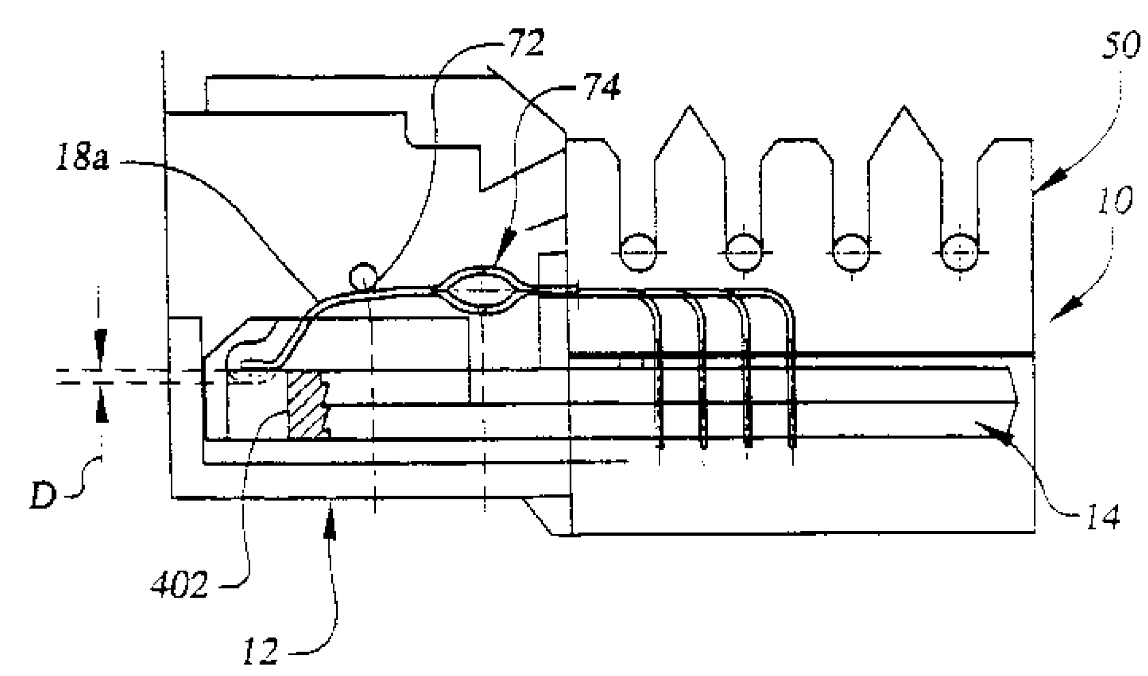
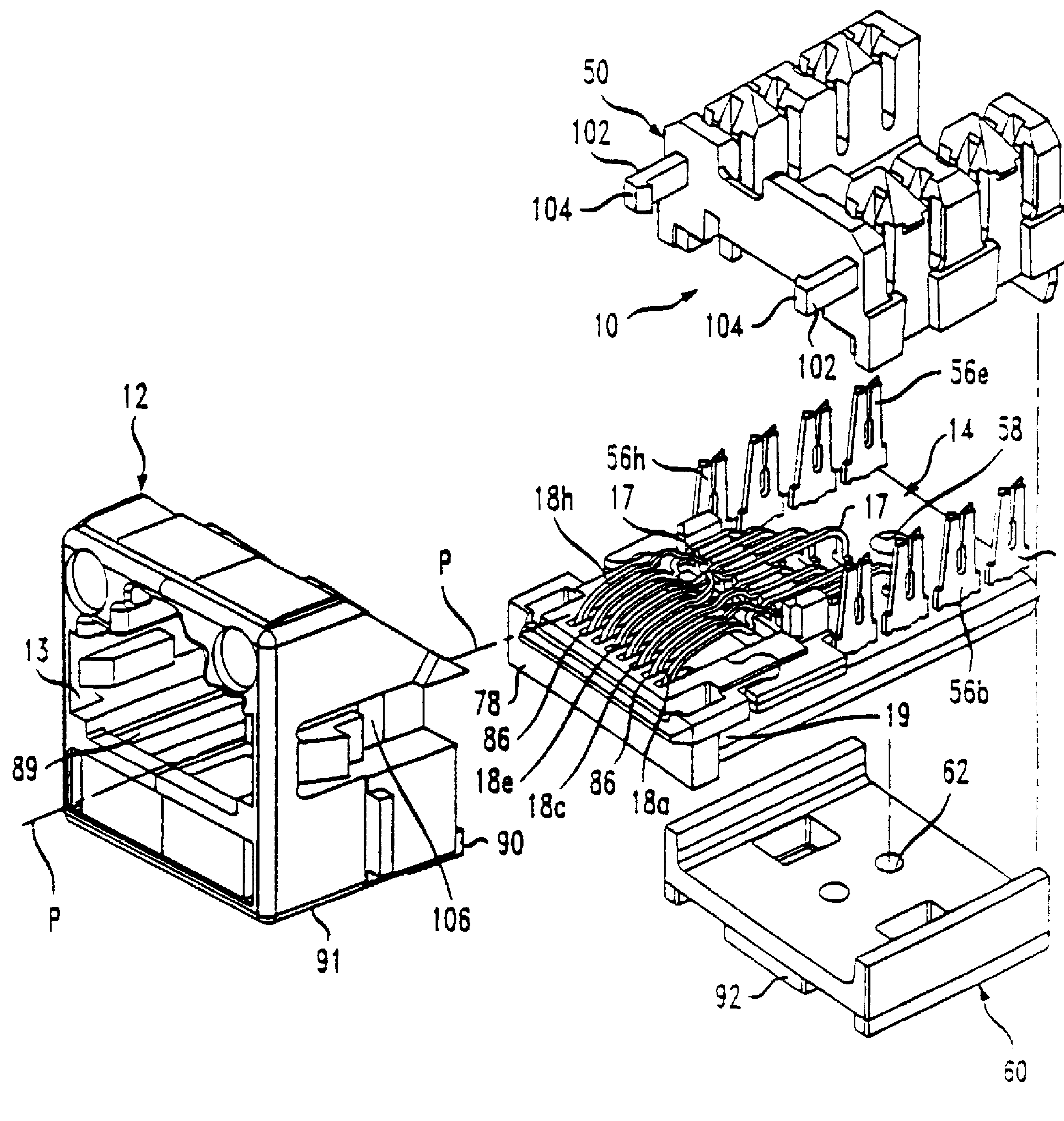


FIG. 1



50
102
104
10
104
102
56e
12
14
58
56h
17
18h
17
56a
P
13
78
56b
86
19
89
18e
86
62
18c
18a
90
P
106
91
92
60

FIG. 2

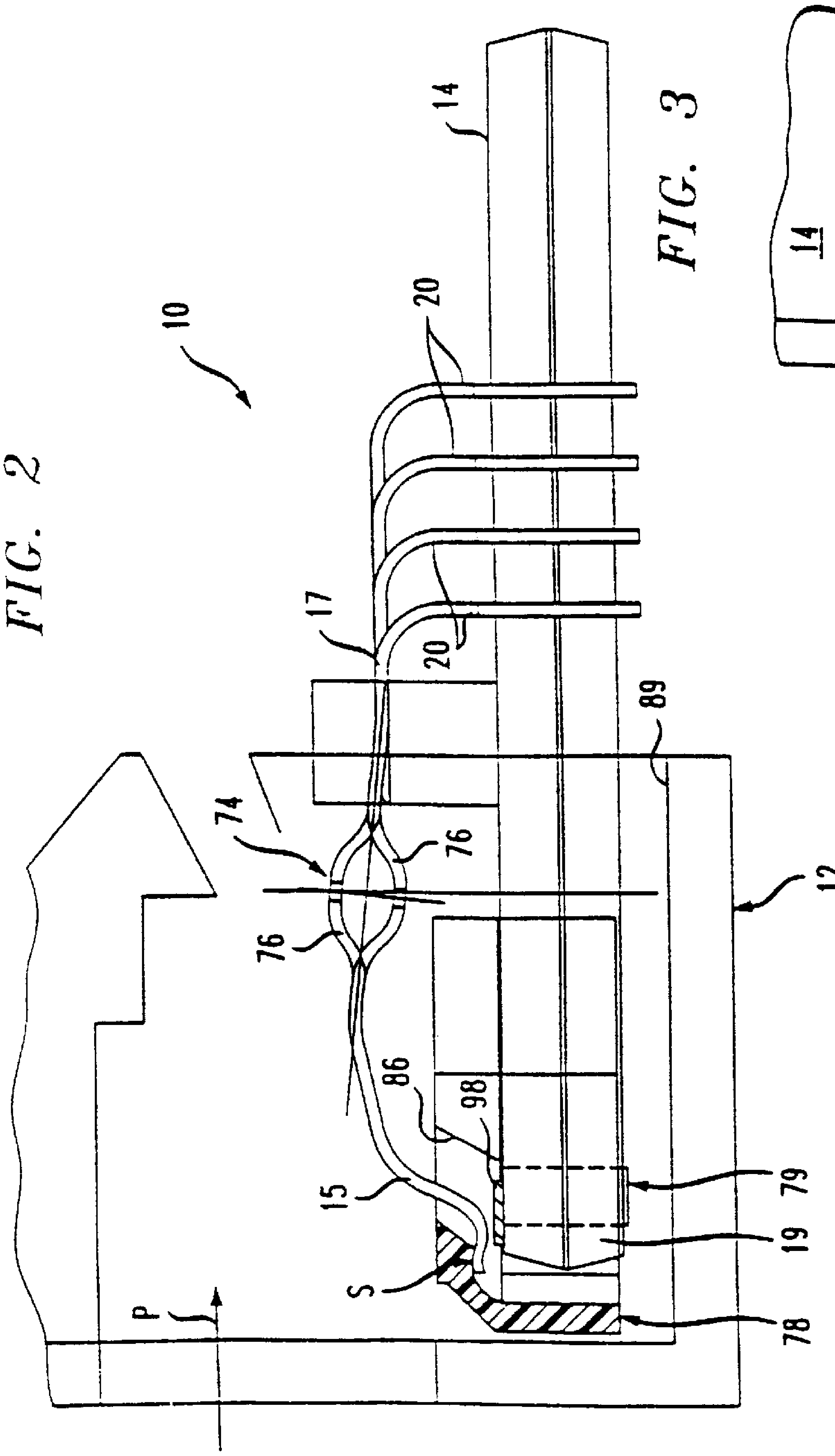
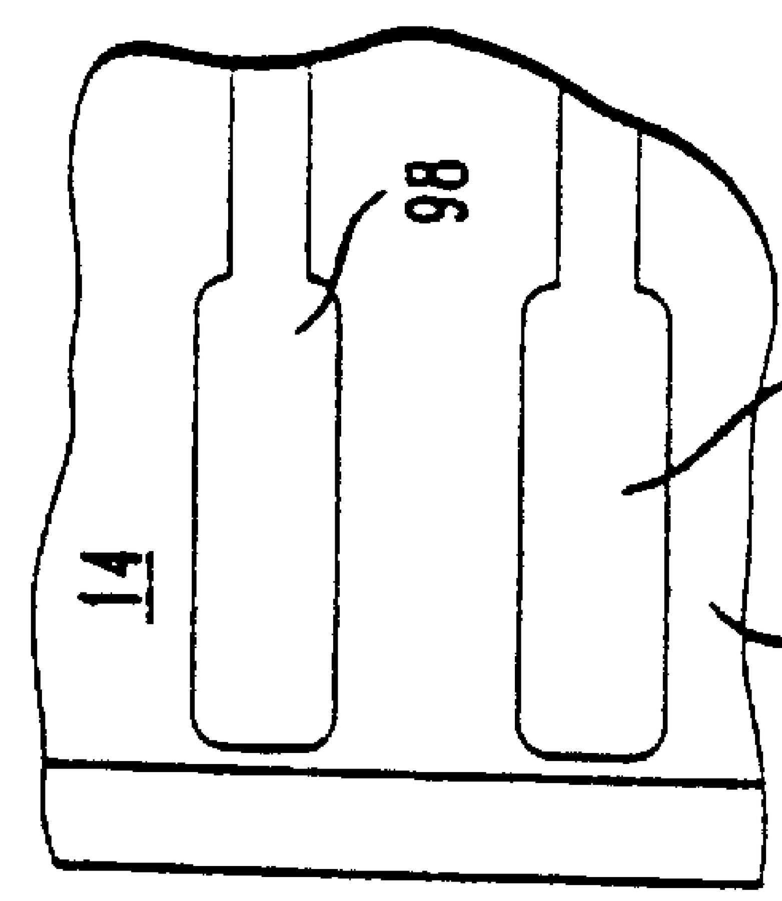


FIG. 3



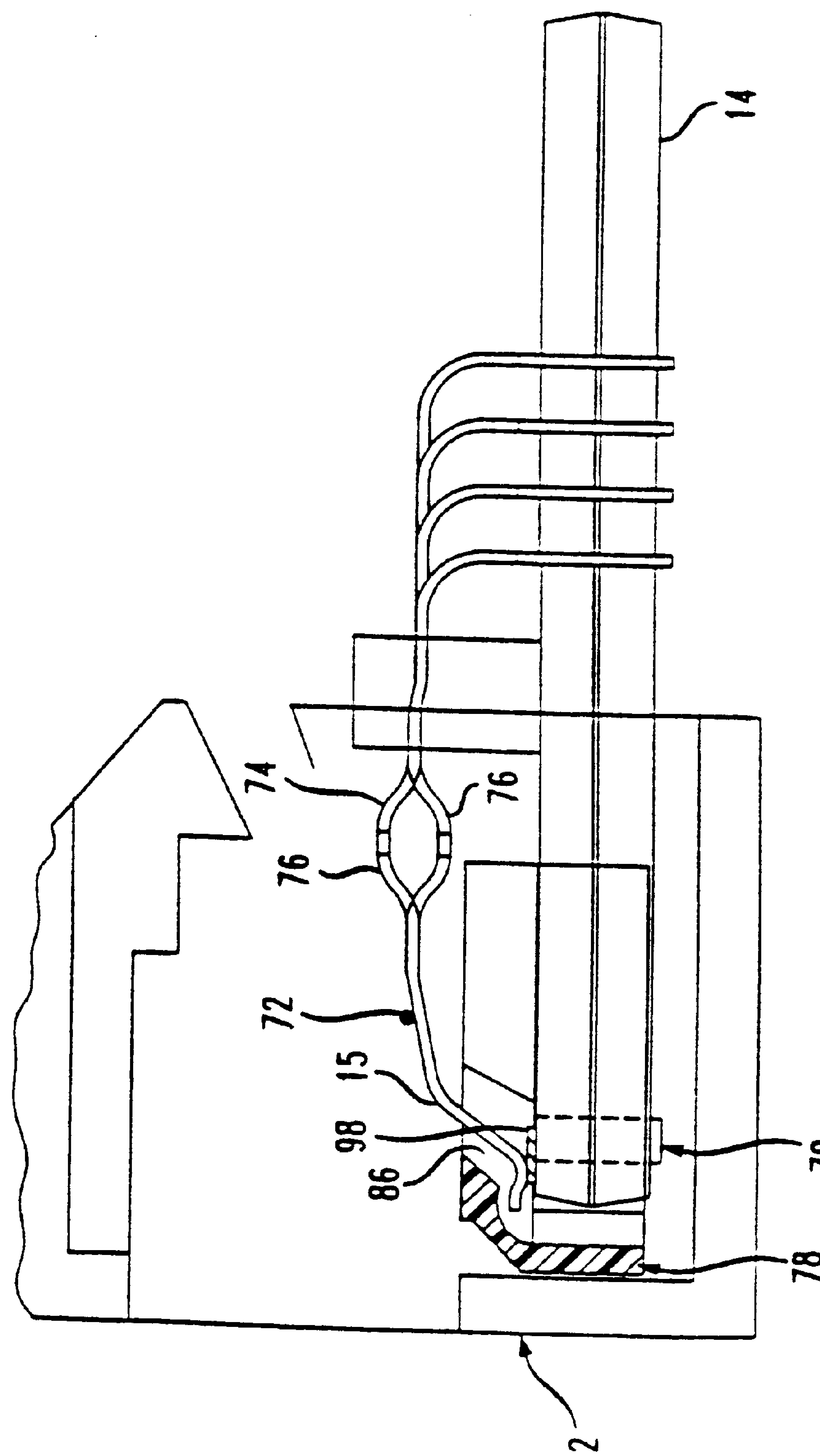


FIG. 4

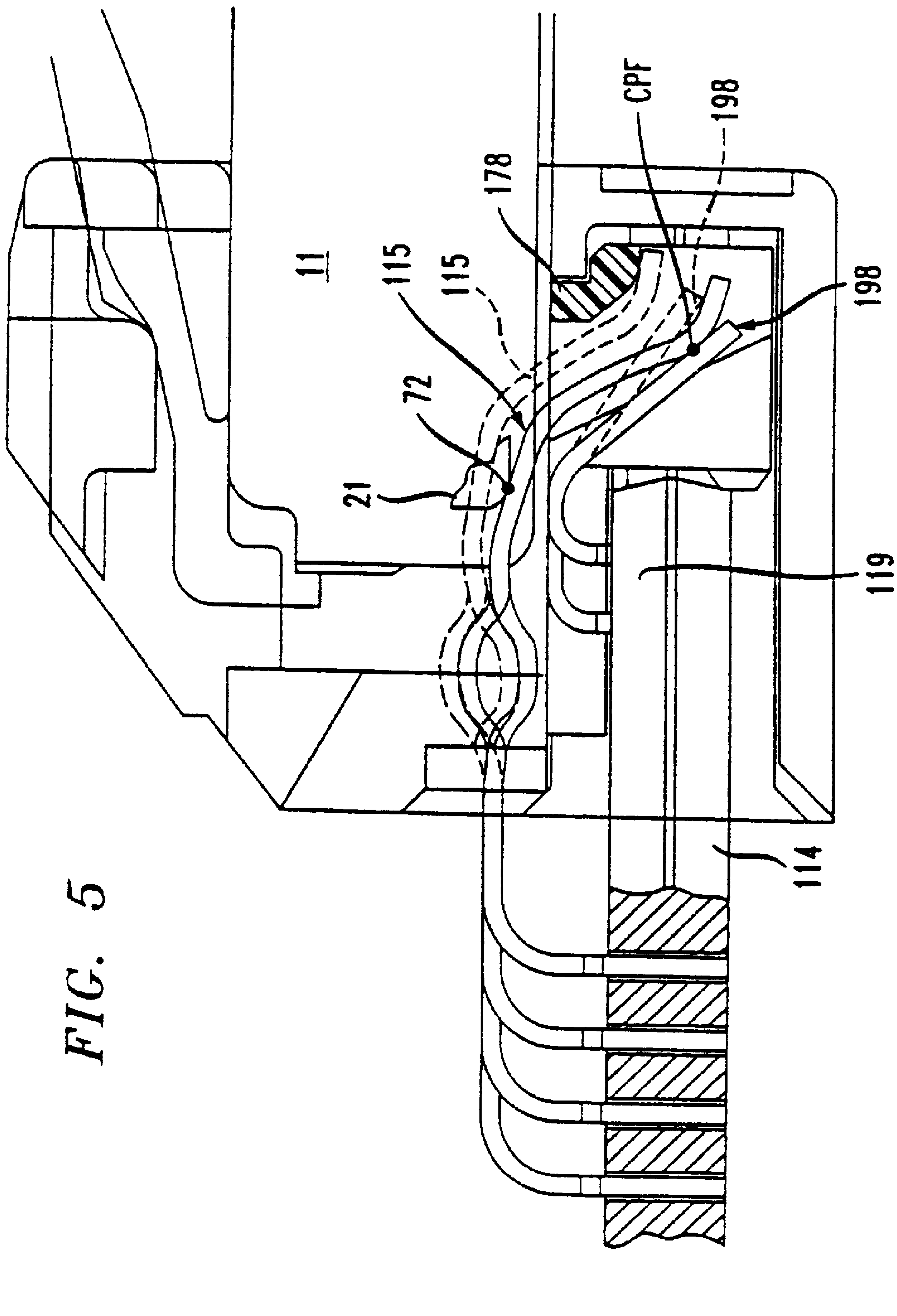


FIG. 5

FIG. 6

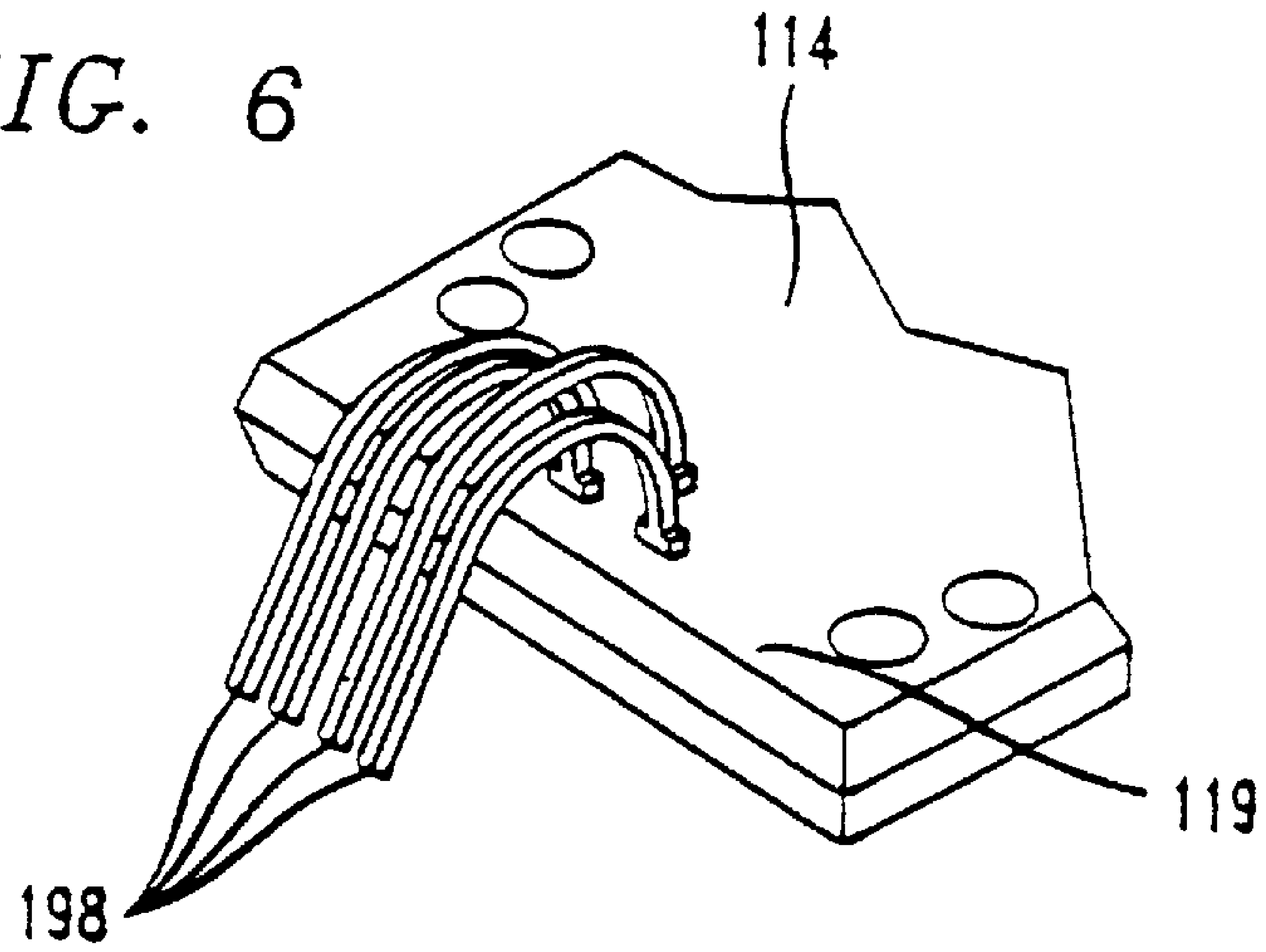


FIG. 7

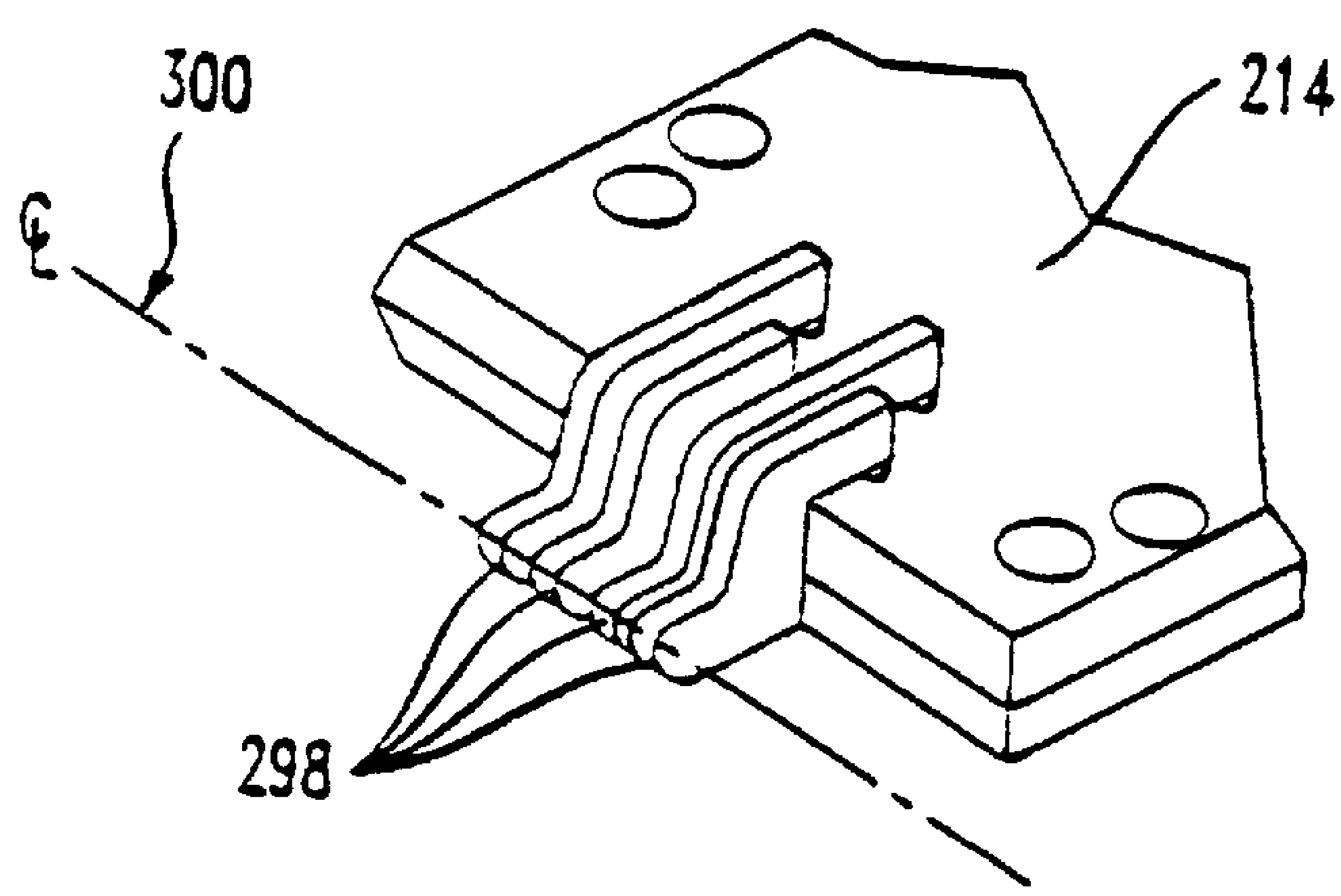


FIG. 8

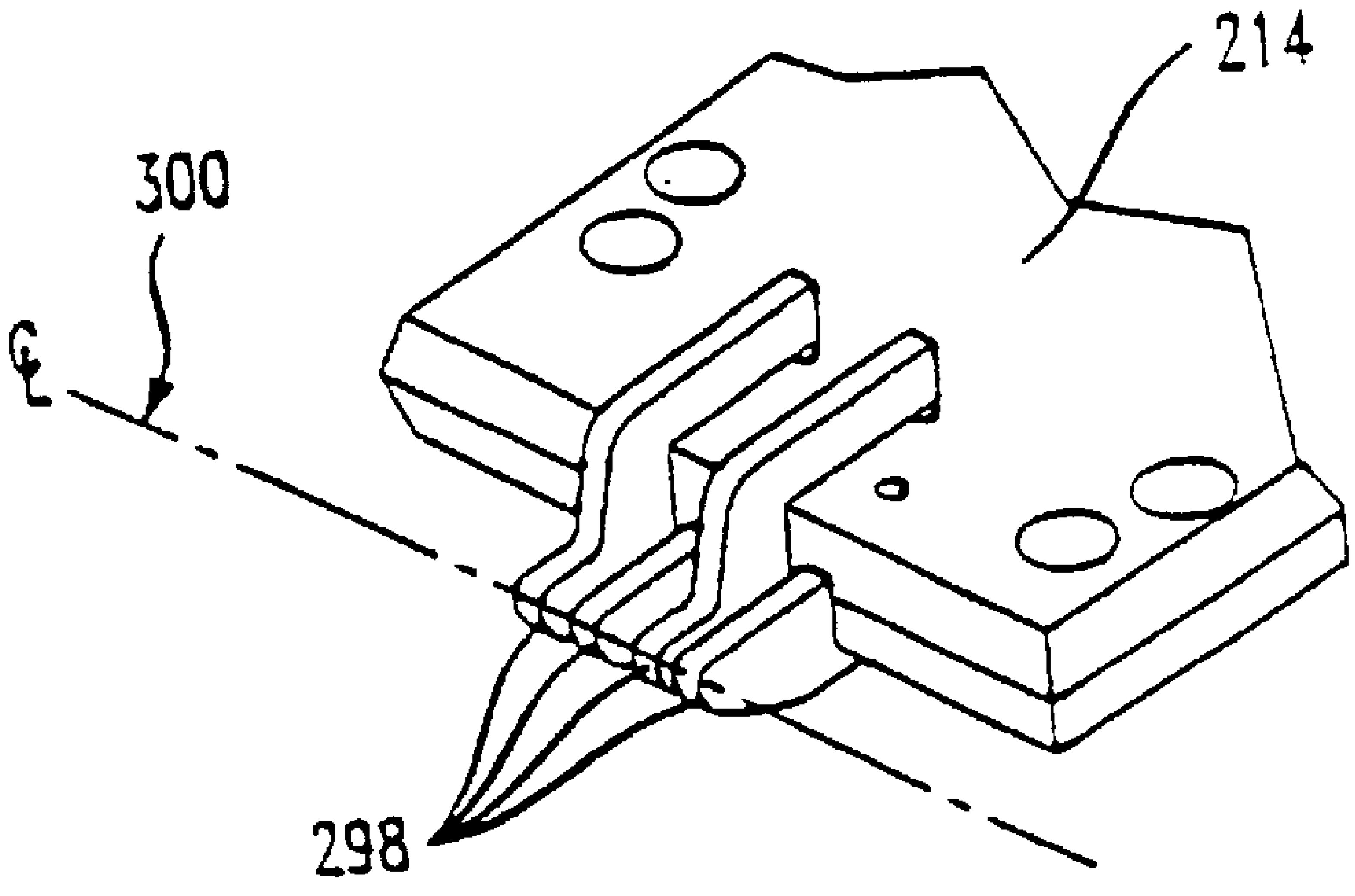


FIG. 9

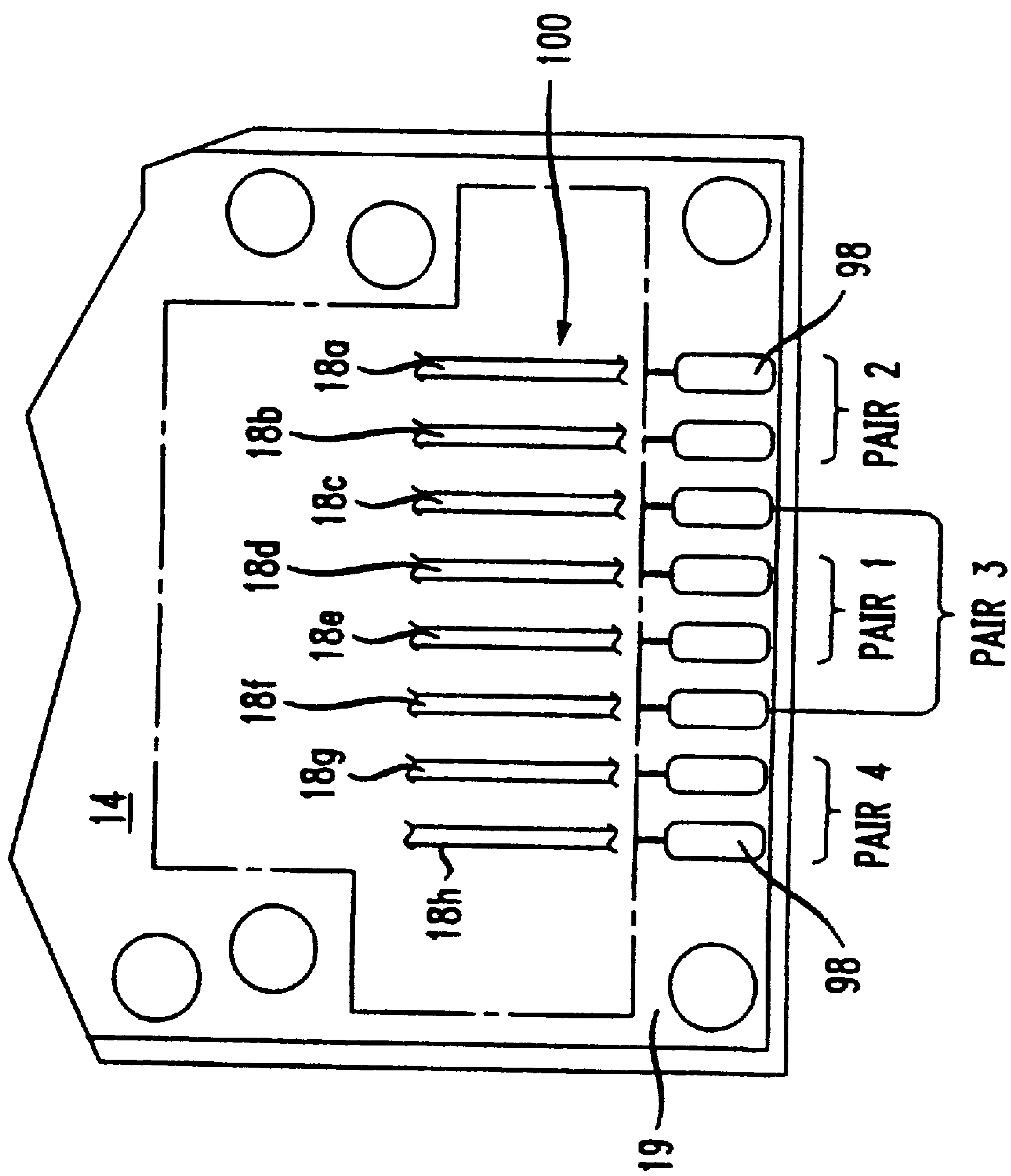

100
98
18a
18b
18c
18d
18e
18f
18g
18h
PAIR 2
PAIR 1
PAIR 3
PAIR 4
14
98
19

FIG. 10

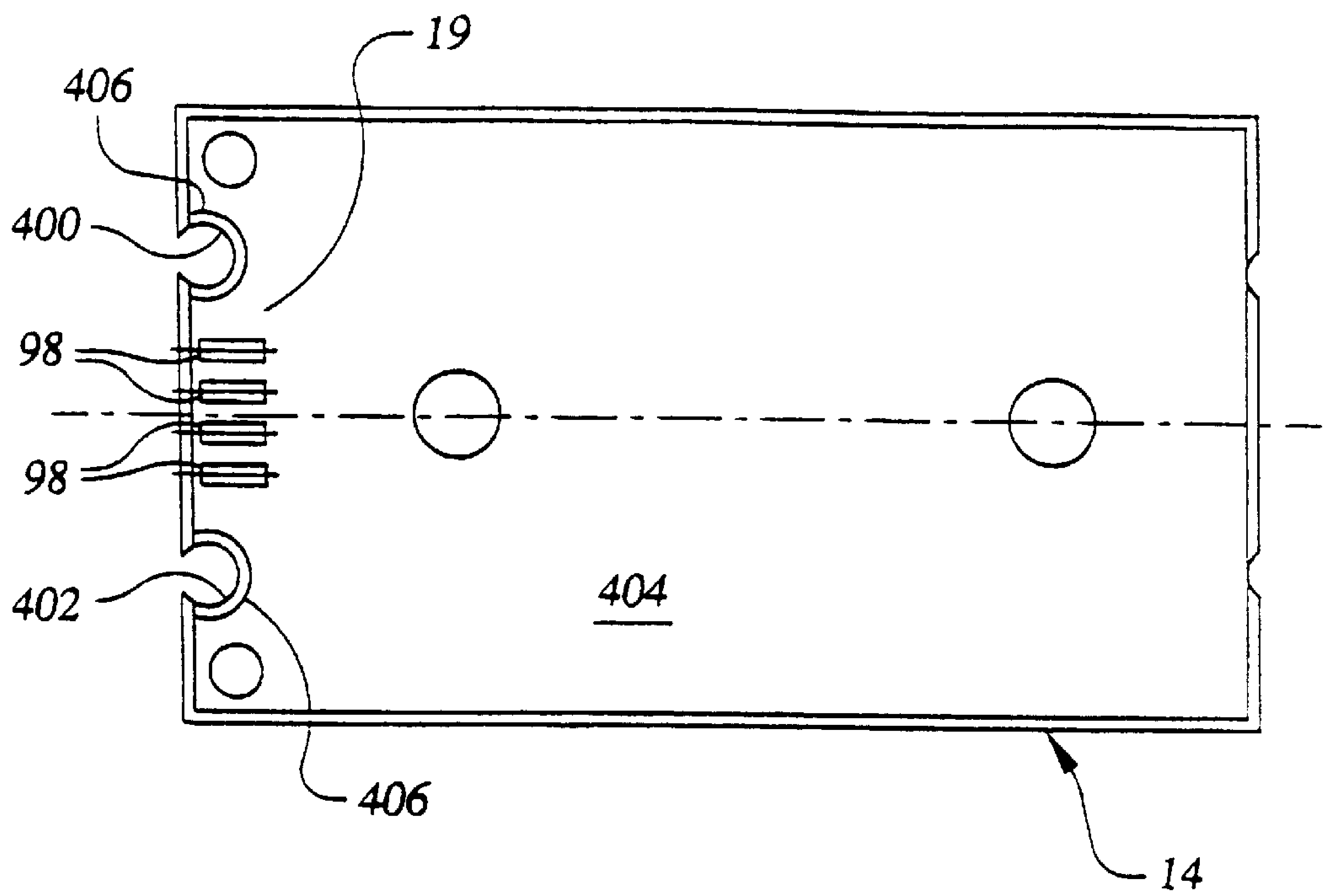
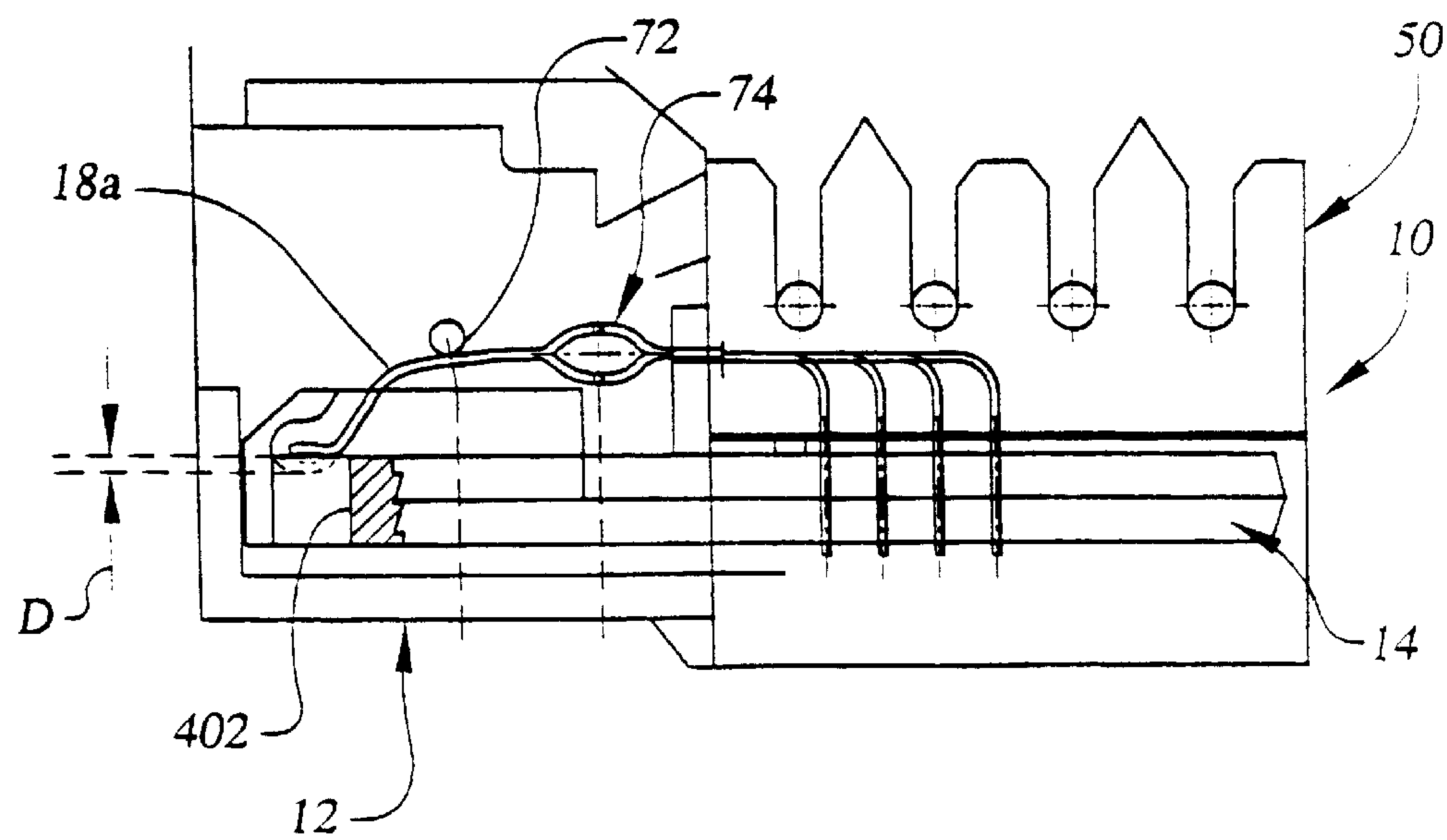


FIG. 11



COMMUNICATION JACK CONNECTOR CONSTRUCTION FOR AVOIDING DAMAGE TO CONTACT WIRES

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. application Ser. No. 09/664,814 filed Sep. 19, 2000, and due to issue as U.S. Pat. No. 6,350,158 on Feb. 26, 2002. This application also claims the priority under 35 U.S.C. §119(e) of U.S. Provisional Application 60/345,662 filed Jan. 2, 2002.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to constructions for communication jack connectors.

2. Discussion of the Known Art

Modern office, laboratory and business environments typically employ both telephone and wired data communication networks (e.g., LANs). While telephone jacks are usually constructed to receive conventional 6-position modular telephone plugs carrying 4 or 6 wires (e.g., types "RJ-11" or "RJ-14"), data jacks are typically constructed to receive 8-position, modular communication plugs which carry 8 wires and conform with EIA/TIA standard 568B (type "RJ-45"). Because the telephone and the data jacks are frequently mounted next to one another, sometimes on a common faceplate or wall plate, it is not unusual for persons mistakenly to try to insert a non-conforming modular telephone plug into a modular data jack with damaging results. That is, a modular telephone plug can permanently deform the endmost contact wires (e.g., contact wires **1** and **8**) of a data jack, since solid (ungrooved) side portions of the plug are wide enough to strike the end contact wires and deflect them beyond tolerable limits as the plug is forced into the jack.

SUMMARY OF THE INVENTION

According to the invention, a communication jack connector assembly includes a wiring board and a number of terminal contact wires extending above the board for engaging and making electrical connections with corresponding terminals of a plug connector along a line of contact, wherein the contact wires have free ends located ahead of the line of contact and the free ends are formed to be deflected resiliently in a direction toward the wiring board when engaging the plug connector. At least one clearance opening is formed in the wiring board at a position where the free end of a corresponding contact wire would otherwise contact an upper surface of the board when engaging the plug connector. The clearance opening is dimensioned so that part of the free end of the contact wire deflects into the opening a certain distance from the upper surface of wiring board, while the contact wire maintains sufficient resilient force to connect electrically with the corresponding terminal of the plug connector.

For a better understanding of the invention, reference is made to the following description taken in conjunction with the accompanying drawing and the appended claims.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. **1** is an assembly view of a communication jack connector;

FIG. **2** is an enlarged, side view of a printed wiring board in the connector of FIG. **1**, and contact wires on the board at a first position out of engagement with compensation coupling contacts at a front edge region of the board;

FIG. **3** is an enlarged plan view of two compensation coupling contacts in the form of pads at the front edge region of the wiring board in FIG. **2**;

FIG. **4** is a side view as in FIG. **2**, showing the contact wires at a second position in engagement with the compensation coupling contacts at the front of the wiring board;

FIG. **5** is a side view of a second embodiment of a communication jack connector;

FIG. **6** is a perspective view of a front edge region of a wiring board in the embodiment of FIG. **5**, showing compensation coupling contacts in the form of stiff wires mounted on the board;

FIG. **7** is a perspective view of a front edge region of a wiring board in a third embodiment of a communication jack connector, showing compensation coupling contacts in the form of metal plates mounted on the wiring board;

FIG. **8** shows an alternate arrangement of the metal plate contacts on the wire board in FIG. **7**;

FIG. **9** is a plan view of the front edge region of the wiring board in the embodiment of FIGS. **1**–**4**;

FIG. **10** is a plan view of a printed wiring board constructed according to the invention; and

FIG. **11** is a side view of a communication jack connector including the wiring board of FIG. **10**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is an assembly view of a communication jack connector **10**. The connector **10** includes a jack housing **12** having a front face in which a plug opening **13** is formed. The plug opening **13** has an axis P along the direction of which a mating plug connector **11** (see FIG. **5**) is insertable into the jack housing.

The connector **10** also includes a generally rectangular printed wiring board **14**. For example, the board **14** may comprise a single or a multi-layered dielectric substrate. A number of elongated terminal contact wires **18*a*–18*h*** extend in a generally horizontal direction with respect to a top surface of the wiring board **14**, and substantially parallel to one another. Connecting portions **17** of the contact wires are spaced a certain distance (e.g., 0.090 inches) from the top surface of the wiring board **14**.

As seen in FIG. **2**, free ends **15** of the connecting portions **17** curve downward toward a front edge region **19** of the wiring board **14**. The free ends **15** are formed to deflect resiliently in the direction of the front edge region **19** of the board when blade contacts **21** of the plug connector **11** wipe over corresponding contact wires of the connector **10** in a direction parallel to the top surface of the board **14** (i.e., along the axis P). See FIG. **5**. The contact wires **18*a*–18*h*** may be formed of a copper alloy such as spring-tempered phosphor bronze, beryllium copper, or the like. A typical cross-section for the contact wires is 0.015 inch wide by 0.010 inch thick.

The connector contact wires **18*a*–18*h*** have associated base portions **20** opposite their free ends **15**. Each base portion **20** is formed to connect a contact wire to one or more conductors (not shown) on or within the wiring board **14**. For example, the base portions **20** may be soldered or press-fit in plated terminal openings formed in the board, to connect with corresponding conductive paths on or within the board. As shown in the drawing, the base portions **20** project in a generally normal direction with respect to the top surface of the wiring board **14**.

In the disclosed embodiment, the base portions **20** are shown as entering the wiring board **14** with a "duo-diagonal" footprint pattern. Alternatively, the base portions may enter the wiring board with other footprints, e.g., a "saw tooth" pattern, as long as there is a sufficient distance between the plated openings in which the base portions are received to avoid electrical arcing, per industry requirements.

The wiring board **14** may incorporate electrical circuit components or devices arranged, for example, on or within a rear portion of the board to compensate for connector-induced crosstalk. Such devices include but are not limited to wire traces printed on or within layers of the board **14**. See, e.g., U.S. Pat. No. 5,997,358 (Dec. 7, 1999).

An electrically insulative, rigid dielectric terminal housing **50** (FIG. **1**) covers a rear portion of the wiring board **14**. Outside insulated wire leads may be connected to insulation displacing connection (IDC) terminals **56***a* to **56***h* on the board, which terminals are only partly surrounded by housing terminal guards. The housing **50** is formed of a rigid plastics or other insulative material that meets all applicable standards with respect to electrical insulation and flammability. Such materials include but are not limited to polycarbonate, ABS, and blends thereof. The housing **50** has, for example, at least one fastening or mounting post (not shown) that projects from a bottom surface of the housing to pass through one or more openings **58** formed to coincide with the long axis of board **14**.

Terminals **56***a*–**56***h* are mounted along both sides of the rear portion of the wiring board **14**, as seen in FIG. **1**. Each of the terminals **56***a*–**56***h* has a mounting portion that is soldered or press fit in a corresponding terminal mounting hole in the board, to connect via a conductive path or trace (not shown) with a corresponding one of the terminal contact wires **18***a*–**18***h*. When the terminal housing **50** is aligned above the IDC terminals **56***a*–**56***h* and then lowered to receive the terminals in corresponding slots in the terminal guards, a fastening post of the housing **50** aligns with and passes through an opening **58** in the board **14**.

A cover **60** is formed of the same or a similar material as the terminal housing **50**. The cover **60** is arranged to protect the rear portion of the wiring board **14** from below. Cover **60** has at least one opening **62** which aligns with a tip of a fastening post of the housing **50**, below the opening **58** in the wiring board. The board is thus captured and secured between the terminal housing **50** and the cover **60**, and the tip of the fastening post is joined to the body of the cover **60** by, e.g., ultrasonic welding, so that the rear portion of the wiring board is protectively enclosed. See U.S. Pat. No. 5,924,896 (Jul. 20, 1999).

The connecting portions **17** of the terminal contact wires, between the base portions **20** and the free ends **15** of the wires, are formed to make electrical contact with corresponding blade contacts **21** of the plug connector **11** (see, e.g., FIG. **5**). A line of contact **72** (see FIGS. **4** & **5**) is defined transversely of the contact wires, along which electrical connections are established between the connector **10** and the blade contacts **21** of the plug connector **11**. As mentioned, when the plug connector **11** is inserted in the opening **13** of the jack housing **12**, the free ends **15** of contact wires **18***a*–**18***h* are deflected in unison and resiliently toward the front edge region **19** of wiring board **14**.

Certain pairs of the terminal contact wires have cross-over sections **74** at which one contact wire of a pair is stepped toward and crosses over the other contact wire of the pair, with a generally "S"-shaped side-wise step **76**. As seen in FIGS. **2** and **4**, the terminal contact wires curve arcuately above and below their common plane at each cross-over section **74**. Opposing faces of the steps **76** in the contact wires are typically spaced by about 0.040 inches, i.e., enough to prevent short circuiting when the contact wires are engaged by the mating connector **11**. The cross-over sections **74** are relatively close to the line of contact **72**, and serve to allow inductive crosstalk compensation coupling to be induced among parallel portions of the terminal contact wires in a region between the cross-over sections **74** and the base portions **20** of the contact wires.

A terminal wire guide block **78** is mounted on the front edge region **19** of the wiring board **14**, as shown in FIGS. **1**, **2** and **4**. The guide block **78** has equi-spaced vertical guide ways **86**. The free ends **15** of the terminal contact wires extend within corresponding ones of the guide ways, and are guided individually for vertical movement when deflected by the blade contacts **21** of the plug connector **11**, as in FIG. **4**. Each guide way **86** is, e.g., 0.020 inch wide, and adjacent ones of the guide ways are separated by 0.020 inch thick walls. The guide block **78** may also have, e.g., ribbed mounting posts **79** that project downward to register with corresponding mounting holes in the wiring board **14** to establish a press-fit.

When in the undeflected position of FIG. **2**, the free ends **15** of the terminal contact wires abut an upper inside surface of each guideway **86**. A determined pre-load force is thus established, which force must then be applied by the blade contacts **21** of the plug connector **11** as the blade contacts wipe against and urge the free ends **15** of the contact wires downward to the position of FIG. **4**.

As they deflect downward, the free ends **15** of the contact wires themselves establish a wiping contact against corresponding compensation coupling contacts in the form of conductive contact pads **98**. See FIGS. **2** & **3**. The pads **98** are arrayed in a row parallel to and near the front edge of the wiring board **14**, and are spaced apart from one another by a distance corresponding to a spacing between the free ends **15** of the terminal contact wires. The guideways **86** of the block **78** serve to keep the free ends **15** aligned and centered with corresponding ones of the contact pads **98** on the wiring board.

The contact pads **98** are connected by conductive paths to, e.g., capacitive crosstalk compensation elements on or within the wiring board **14**. Accordingly, when the terminal contact wires **18***a*–**18***h* are engaged by a mating connector, certain pairs of contact wires will be capacitively coupled to one another by compensation elements connected to the corresponding contact pads **98**. Note that the free ends **15** are ahead of and near the line of contact **72** with the mating connector. Crosstalk compensation coupling is thus introduced onto non-current carrying portions of the contact wires, and operates at the connector interface (i.e., the line of contact **72**) where such coupling can be most effective.

FIG. **3** is an enlarged view of two adjacent contact pads **98**. Each pad is typically, e.g., 0.018 inches wide, and side edges of the pads are typically spaced apart from one another by, e.g., 0.022 inches to meet a specified 1000 volt breakdown requirement. Corners of the contact pads **98** are preferably rounded with a radius of, e.g., 0.004 inches.

Crosstalk compensation elements or devices that are coupled to the contact pads **98** are provided in a region **100** on or within the wiring board **14**, in the vicinity of the pads **98** at the front edge region **19** of the wiring board **14**. See

FIG. 9. Compensation elements within the region **100** preferably are not part of any other capacitive or inductive compensation circuitry that may be incorporated at other portions (e.g., toward the rear) of the board **14**. Placing the compensation elements close to the associated contact pads **98** enhances the effect of such elements at the connector interface.

The wiring board **14** including the front edge region **19** with the array of contact pads **98**, may be supported within space available in existing jack frames such as, e.g., jack frames provided for the types "MGS 300" and "MGS 400" series of modular connectors available from Avaya Inc.

The wiring board **14** with the guide block **78** mounted at front edge region **19**, is inserted in a passage **89** that opens in a rear wall of the jack housing **12**. See FIGS. **1** & **2**. Side edges of the board **14** are guided for entry into the housing **12** by, e.g., flanges that project from inside walls of the jack housing **12**. The jack housing has a slotted catch bar **90** (FIG. **1**) protruding rearwardly from a bottom wall **91** of the housing. The bar **90** is arranged to capture a lip **92** that projects downward beneath the wiring board cover **60**. When the wiring board **14** is secured in the jack housing **12**, the top surface of the board is parallel to the plug opening axis P along the direction of which the plug connector **11** may engage and disengage the free ends **15** of the contact wires **18***a*–**18***h*.

Further, in the present embodiment, two side catches **102** project forward from both sides of the terminal housing **50**, and the catches **102** have hooked ends **104** that snap into and lock within recesses **106** formed in both side walls of the jack housing **12**. Thus, all adjoining parts of the connector **10** are positively joined to one another to reduce movement between them, and to maintain rated connector performance by reducing variation in relative positions of the connector parts when finally assembled.

FIGS. **5** and **6** show a front edge region **119** of a wiring board **114** in a second embodiment of a connector assembly. In the second embodiment, free ends **115** of the terminal contact wires project forwardly beyond the front edge region **119** of the board **114**. A number of arcuate, stiff wire contacts **198** are mounted at the front edge region **119**, and are aligned beneath corresponding free ends **115** of the contact wires.

FIG. **5** shows, in dotted lines, the position of the free ends **115** of the terminal contact wires in a pre-loaded state, resting against upper ledges in the guide ways of a guide block **178** mounted on the wiring board **114**. FIG. **5** also shows an initial position of the contacts **198** in dashed lines. When the mating plug connector **11** is received in the jack frame, the free ends **115** of the terminal contact wires deflect resiliently downward. The wire contacts **198** mounted on the board are then engaged by the free ends of those terminal contact wires aligned above them, as shown in solid lines in FIG. **5**. Like the first embodiment, this arrangement introduces crosstalk compensation coupling via associated compensation elements disposed on or within the wiring board **114**, near the wire contacts **198**.

FIGS. **7** and **8** show a third embodiment wherein compensation coupling contacts **298** are in the form of non-compliant conductive members, e.g., stamped metal plates. The metal plates may have, for example, compliant "needle-eye" mounting bases (not shown) dimensioned and formed to be press-fit into corresponding plated terminal openings in an associated wiring board **214**. As the free ends of the terminal contact wires deflect downward, they make contact with corresponding ones of the metal plates along a contact line **300**. FIG. **8** shows an arrangement wherein the mounting bases of adjacent metal plates **298** enter the wiring board **214** from opposite sides of the board, thus reducing potential offending crosstalk that might otherwise be induced among the plates **298**.

FIG. **9** is a view of the front edge region **19** of the wiring board **14** in the embodiment of FIGS. **1**–**4**, showing eight contact pads **98**. Each of the pads is disposed on the board **14** in operative relation beneath a free end of an associated terminal contact wire (not shown). Capacitive compensation coupling was introduced between pairs of the pads by way of wire traces or elements embedded within the region **100** on the board **14**, as detailed later below. The rightmost pad **98** in FIG. **9** is associated with contact wire **18***a* in FIG. **1**, and the leftmost pad in the figure is associated with contact wire **18***h*. Four pairs of the eight contact wires define four different signal paths in the connector **10**, and the signal-carrying pairs of contact wires are identified by number as follows with reference to FIG. **9**.

PAIR NO.	CONTACT WIRES
1	18d and 18e
2	18a and 18b
3	18c and 18f
4	18g and 18h

Values of capacitive compensation coupling introduced via the pads **98** associated with the contact wires, were as follows.

Pads 98 associated with contact wires	Capacitance (picofarads) between pads
18a and 18c	0.04
18a and 18d	0.04
18b and 18e	0.09
18b and 18f	0.42
18c and 18e	1.25
18d and 18f	1.25

NEXT measurements were performed with the above values of capacitive coupling introduced via the pads **98** between the free ends of the contact wires. Some crosstalk compensation was also provided in a region of the wiring board **14** outside the region **100**. Category **6** performance was met or exceeded among all four signal-carrying pairs of the contact wires in the connector **10**.

FIGS. **10** and **11** show a construction according to the invention for avoiding damage to outermost terminal contact wires, e.g., contact wires **18***a* and **18***h* in the embodiment of FIGS. **1**–**4**, under certain conditions. As mentioned earlier, the outermost contact wires may be permanently deformed and rendered inoperative when an attempt is made to force a conventional six position, 4- or 6-wire telephone plug into an eight position jack such as the jack connector **10** of FIGS. **1**–**4**. Because data jacks are commonly mounted immediately adjacent to telephone jacks, mistaken attempts to insert telephone plugs into data jacks, with consequent damaging results, are quite common.

Conventional six position modular telephone plugs have continuous outer end surfaces at those positions where recesses are formed in an eight position data plug for receiving the leading ends of the outermost jack contact wires, e.g., wires **18***a* and **18***h* in FIG. **1**. The continuous end surfaces on the telephone plugs extend about 0.023 inch above recessed contact blades in the plugs, and will therefore cause the leading ends of the outermost jack contact wires to deflect at least 0.023 inch farther than normal and thus deform permanently. Such over-deflection may also result in a reduced contact force between the outermost jack contact wires and the corresponding contact blades of a conforming data plug (typically 100 grams) to unsafe levels if the conforming plug is later inserted in the jack.

As seen in FIGS. **10** and **11**, two breakout or clearance openings **400**, **402** are formed in the front edge region **19** of the printed wiring board **14**, where leading or free ends of the terminal contact wires **18***a* and **18***h* would otherwise physically touch the board when deflected by an inserted plug connector. The openings **400**, **402** are located and configured so that the free ends of the contact wires **18***a*, **18***h* may enter the openings and be allowed to deflect below the level of the top surface **404** of the wiring board **14** by a distance D (FIG. **11**) of about 0.018 inch in response to insertion of either a conforming eight position data plug, or a non-conforming six position telephone plug. By limiting the additional range of movement to 0.018 inch, major over-stressing of the outermost contact wires is prevented while sufficient resilient force is left available for the contact wires to connect electrically with the corresponding blade terminals on a conforming plug connector.

Walls of the breakout openings **400**, **402** may also be plated as at **406** in FIG. **10**, to allow components on or within the wiring board **14** to connect electrically with the free ends of the outermost contact wires for purposes of, e.g., crosstalk compensation. In such a case, the breakout openings **400**, **402** should be located and formed so that in addition to averting overstressed conditions of the outermost contact wires, the leading ends of those wires will be urged against the plated walls of the openings with sufficient force to establish reliable electrical connections when the contact wires are deflected by a conforming plug connector.

While the foregoing description represents preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made, without departing from the spirit and scope of the invention pointed out by the following claims.

We claim:

1. A communication jack connector assembly, comprising:

a wiring board having a front region; and

a number of elongated terminal contact wires extending above the wiring board for engaging and making electrical connections with corresponding terminals of a conforming plug connector along a line of contact, wherein the terminal contact wires have free ends located ahead of said line of contact, and the free ends are formed to be deflected resiliently in a direction toward the front region of the wiring board when engaging the plug connector;

wherein at least one clearance opening is formed in the front region of the wiring board at a position where the free end of a corresponding contact wire would otherwise contact an upper surface of the board when engaging the plug connector, and the clearance opening is dimensioned so that part of the free end of the corresponding contact wire deflects into the clearance opening a certain distance from the upper surface of wiring board while the contact wire maintains sufficient resilient force to connect electrically with the corresponding terminal of the plug connector.

2. A jack connector assembly according to claim **1**, wherein the two clearance openings are formed at positions on the wiring board to correspond with two outside terminal contact wires.

3. A jack connector assembly according to claim **1**, wherein said certain distance is sufficient to prevent the corresponding contact wire from being permanently deformed when deflected by a non-conforming plug connector.

4. A communication jack connector, comprising:

a jack housing having a plug opening, the plug opening having an axis and the housing being constructed and arranged for receiving a conforming plug connector in the plug opening along the direction of the plug axis; and

a communication connector assembly supported within the jack housing, for electrically contacting said conforming plug connector when the plug connector is received in the jack housing, the connector assembly including:

a wiring board having a front region; and

a number of elongated terminal contact wires extending above the wiring board for engaging and making electrical connections with corresponding terminals of the conforming plug connector along a line of contact, wherein the terminal contact wires have free ends located ahead of said line of contact, and the free ends are formed to be deflected resiliently in a direction toward the front region of the wiring board when engaging the plug connector;

wherein at least one clearance opening is formed in the front region of the wiring board at a position where the free end of a corresponding contact wire would otherwise contact an upper surface of the board when engaging the plug connector, and the clearance opening is dimensioned so that part of the free end of the corresponding contact wire deflects into the clearance opening a certain distance from the upper surface of the wiring board while the contact wire maintains sufficient resilient force to connect electrically with the corresponding terminal of the plug connector.

5. A jack connector according to claim **4**, wherein the two clearance openings are formed at positions on the wiring board to correspond with two outside terminal contact wires.

6. A jack connector according to claim **4**, wherein said certain distance is sufficient to prevent the corresponding contact wire from being permanently deformed when deflected by a non-conforming plug connector inserted in the plug opening of the jack housing.

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